TWO-WAVELENGTH DIFFRACTIVE OPTICAL DEVICE, TWO- WAVELENGTH LIGHT SOURCE DEVICE AND OPTICAL HEAD DEVICE

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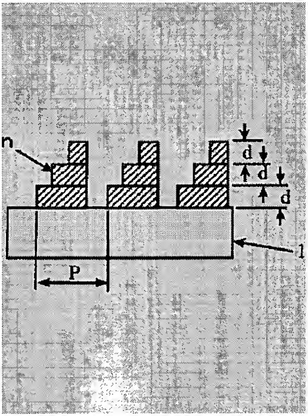
Abstract of **JP2002062415**

PROBLEM TO BE SOLVED: To obtain a two-wavelength diffractive optical device having high transmittance and high diffraction efficiency in which stair-like steps in a smaller number of steps than a conventional pseudo-blazed diffraction grating are formed where light at the wavelength &lambda 1 and light at the wavelength &lambda 2 (&lambda 2<&lambda 2) enters, and to provide a device in which stable recording and reproducing of information can be performed with good S/N and a smaller number of parts by mounting the above device on an optical head device.
SOLUTION: The two-wavelength diffractive optical device 1 consists of a pseudo-blazed diffraction grating having stair-like steps of N steps (N is 2, 3, or 4) with the optical path difference R caused by the height d of one step in the stair-like steps satisfying the relation of (N-1)&lambda 2/N<R<&lambda 1. The obtained device is combined with a two-wavelength semiconductor laser having the position of light emission point different from that of the device and mounted on an optical head device.



DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the diffraction optical element for two waves, two-wave light equipment, and an optical head device.
[0002]
[Description of the Prior Art]In the optical head device which records and plays the information on the optical recording medium (it is hereafter described as an optical disc) using optical discs, such as CD and DVD, The optical head device whose accuracy of position of the emission point was highly stable is obtained by arranging the semiconductor laser for two waves which separated 100-300 micrometers of the emission point interval, and arranges and constituted the semiconductor laser with a wavelength of 790 nm and the semiconductor laser with a wavelength of 650 nm in one light source unit. Part mark are reduced, a miniaturization and weight saving of an optical head device are attained, and since there is an advantage of being able to simplify the design of an optical system, the composition of various optical head devices is proposed to the miniaturization and the weight saving.
[0003]For example, in drawing 5 (a) and drawing 5 (b), the emitted light from the emission point 2A with a wavelength of 650 nm of the semiconductor laser 2 for two waves and emission point 2B with a wavelength of 790 nm is reflected, after being considered as a parallel beam with the collimate lens 4 and being condensed on the information storage side of the optical disc 5 with the object lens 3. This catoptric light is led to the acceptance surface of a photodetector via the beam splitter 6, and the information on an optical disc is changed into an electrical signal. That is, as shown in drawing 5 (a), the emitted light from the emission point 2A of a semiconductor laser with a wavelength of 650 nm is condensed by the photodetector 7A. On the other hand, the emitted light from emission point 2B of a semiconductor laser (drawing 5 (b)) with a wavelength of 790 nm is condensed by the acceptance surface of the photodetector 7B.
[0004]As shown in drawing 5 (a) and drawing 5 (b), when the emission point 2A and 2B of a semiconductor laser separated distance and existed, the photodetectors 7A and 7B needed to be detached according to the size of the interval of the emission point 2A and 2B. Therefore, there was a problem to which the electrical signal processing circuit which accompanies a photodetector and it becomes complicated. When each acceptance surface of the photodetectors 7A and 7B was simplified (it is considered as the thing of one sheet in all), there was a problem to which a photodetector is enlarged and speed of response falls. To the problem of this enlargement, the light of wavelength λ_1 is penetrated and the light emitted from a different emission point can be condensed to the

same photodetector by using the optical element which deflects the light of wavelength $lambda_2$, without increasing the area of the acceptance surface of a photodetector.

[0005]The above-mentioned optical element is a diffraction grating. For example, in drawing 1, the optical path difference based on the level difference d of the stair-like step of a false blazed diffraction grating is made into a wavelength $lambda_1$=650nm integral multiple. In this case, it uses that the optical path difference does not become an integral multiple of wavelength $lambda_2$ to wavelength $lambda_2$=790nm, and although the light of wavelength $lambda_1$ is made to penetrate, the light of wavelength $lambda_2$ can be made to diffract. Do not diffract but the light of wavelength $lambda_1$ is made to penetrate in rectilinear propagation between two lights which included the above-mentioned optical element in the optical head device, and emitted it from a different emission point, and the light of wavelength $lambda_2$ is making it diffract, and coincides the optic axis of the light of wavelength $lambda_2$ with the optic axis of the light of wavelength $lambda_1$. By coincidence of this optic axis, two lights can be condensed to the same photodetector, without increasing the area of a photodetector.

[0006]

[Problem(s) to be Solved by the Invention]However, in order to make diffraction efficiency over the light of wavelength $lambda_2$ not less than 60% based on the principle of the aforementioned diffraction, the number of steps needed to be enlarged with 5-7 steps. Therefore, since the total level difference becomes large and the working shape of a lattice is also complicated, It was difficult for both the transmission efficiency of the light of wavelength $lambda_1$ and the diffraction efficiency of the light of wavelength $lambda_2$ to fall under the influence of a lattice side attachment wall (field of the level difference direction of a lattice), and to be stabilized with both sufficient yields and to make such efficiency into not less than 60%.

[0007]

[Means for Solving the Problem]It is a diffraction optical element for two waves which is made in order that this invention may solve an above-mentioned technical problem, and penetrates light of wavelength $lambda_1$, and light of wavelength $lambda_2$ (however, $lambda_1$<$lambda_2$), Said diffraction optical element for two waves is a false blazed diffraction grating which has a stair-like step of N stage (however, N 2, 3, or 4), A diffraction optical element for two waves, wherein the optical path difference R based on one level difference of said stair-like step fills relation between x(N-1) $lambda_2$ / N<R<$lambda_1$ is provided.

[0008]A semiconductor laser for two waves which emits light of wavelength $lambda_1$, and light of wavelength $lambda_2$ (however, $lambda_1$<$lambda_2$) from a different emission point, It is two-wave light equipment provided with a diffraction optical element for two waves which penetrates light of wavelength $lambda_1$ and wavelength $lambda_2$, When two lights, wavelength $lambda_1$ and wavelength $lambda_2$, which said diffraction optical element for two waves is the above-mentioned diffraction optical element for two waves, and were emitted from said semiconductor laser for two waves penetrate said diffraction optical element for two waves, The two-wave light equipment of two lights constituted so that an optic axis may be in agreement, respectively is provided.

[0009]A semiconductor laser for two waves which emits light of wavelength $lambda_1$, and

light of wavelength $lambda_2$ (however, $lambda_1<lambda_2$), An object lens which condenses emitted light from said semiconductor laser for two waves to an optical recording medium, . Have a photodetector which receives catoptric light which it was condensed and was reflected in respect of the information storage of an optical recording medium. It is an optical head device which performs record and reproduction of information on an optical recording medium, and the above-mentioned diffraction optical element for two waves provides an optical head device currently installed into an optical path between said photodetector and said object lens in an optical path between said semiconductor laser for two waves, and said object lens.

[0010]

[Embodiment of the Invention]The diffraction optical element for two waves of this invention is a diffraction optical element for two waves which penetrates the light of wavelength $lambda_1$, and the light of wavelength $lambda_2$ (however, $lambda_1<lambda_2$), and is a false blazed diffraction grating which has a stair-like step of N stage (however, N 2, 3, or 4). The oblique side portion of the serration shape of a blazed diffraction grating is replaced on stairs, and all the level differences of stairs are equal to a false blazed diffraction grating. The stair-like step of N stage means the stair-like step of a number of stages in case the number of the level differences of stairs is N-1. That is, let the number which added 1 to the number of level differences be a number of stages. And it is made for the optical path difference R based on the level difference of the stair-like step of the diffraction optical element for two waves to fill the relation between $x(N-1)\ lambda_2 / N<R<lambda_1$.

[0011]The wavelength used is usually decided with a semiconductor laser. There are two kinds of wavelength $lambda_1$ of the shorter one, and the wavelength range centering on 405 nm and their wavelength range centering on 650 nm are typical. When $lambda_1$ is a wavelength range centering on 405 nm, wavelength $lambda_2$ of the longer one has 650, 780, or a typical wavelength range centering on 790 nm. When $lambda_1$ is a wavelength range centering on 650 nm, wavelength $lambda_2$ of the longer one has a typical wavelength range centering on 790 nm.

[0012]That is, when taking the value of the range of 385-425 nm as wavelength $lambda_1$, the value of the range of 630-650 nm or the value of the range of 760-810 nm can be taken as wavelength $lambda_2$. When taking the value of 630-670 nm as wavelength $lambda_1$, the value of 770-810 nm can be taken as wavelength $lambda_2$.

[0013]The wavelength $lambda_1$=650nm light of a DVD system and the wavelength $lambda_2$=790nm light of a CD system enter into the diffraction optical element for two waves of this invention, for example. The diffraction optical element 1 for two waves shown in drawing 1 is a false blazed diffraction grating which has a stair-like step of the number of stages N= 4. The optical material processed into the false blazed diffraction grating has the refractive index n. The lattice of a false blazed diffraction grating is periodic, a lattice pitch is P, and a lattice is linear shape when a diffraction grating is superficially seen from a top. In drawing 1, although all the step sizes of the direction of lattice pitch P of a stair-like step are the same, a step size is not limited to this.

[0014]The optical path difference R fills the relation between $x(N-1)\ lambda_2 / N<R<lambda_1$. Therefore, if the optical path difference R becomes close to $lambda_1$ and

the light of wavelength $lambda_1$ penetrates a diffraction grating, the light of wavelength $lambda_1$ will have few phase changes, and it will become high transmissivity. If the optical path difference R becomes close to $x(N-1)$ $lambda_2/N$ and the light of wavelength $lambda_2$ penetrates a diffraction grating, a diffraction grating will function as a false blazed diffraction grating of the number of stages N, and the light of wavelength $lambda_2$ will be diffracted with high diffraction efficiency in the specific angle direction decided by lattice pitch P. Here, the angle of diffraction of the incident light of wavelength $lambda_2$ serves as $theta_1$ by making lattice pitch P equal to $lambda_2/sintheta_1$.

[0015]If N is set to 2, 3, or 4, a false blazed diffraction grating will serve as a size to which the transmissivity to the light of wavelength $lambda_1$ and the diffraction efficiency over the light of wavelength $lambda_2$ are suitable for use. Especially at both the times of N= 4, transmissivity and diffraction efficiency are high, and the utilization efficiency of light becomes high and is preferred. A stair-like step is not formed as N is 1. Although transmissivity [as opposed to / that N is five or more / the light of wavelength $lambda_1$] becomes high, the area of a lattice side attachment wall (field of the level difference direction of a lattice) increases, and the diffraction efficiency over the light of wavelength $lambda_2$ becomes low under the influence of the interaction of a lattice side attachment wall and light, and is low unsuitable. [of the utilization efficiency of light]

[0016]As a method of producing this false blazed diffraction grating, for example on a substrate, after carrying out the coat of the optical material to predetermined thickness, a level difference may be formed with an etching method, and a substrate may be made direct with an etching method and may be formed. Press working of sheet metal of the substrate may be carried out using the metallic mold furthermore formed in false blaze shape.

[0017]A coat is carried out on a substrate, as an optical material etched, there are a SiO_2 film, a TiO_2 film, a SiON film, etc., and the material which does not have birefringence, such as a glass substrate and a quartz substrate, can be used as a coat board. Materials which can be etched efficiently, such as synthetic quartz, can be used as a substrate (optical material) processed by an etching method. There are few impurities, and especially synthetic quartz is excellent in the optical characteristic, and its stability is well preferred. When the value of 630-670 nm is taken as wavelength $lambda_1$ and the value of 770-810 nm is taken as wavelength $lambda_2$, the diffraction efficiency and transmission efficiency of light become high to the number of stages processed, and it is desirable.

[0018]The two-wave light equipment which used the diffraction optical element for two waves of this invention next is explained. In this invention, it is two-wave light equipment provided with the semiconductor laser for two waves which differs the light of wavelength $lambda_1$, and the light of wavelength $lambda_2$ and which is emitted from an emission point, and the diffraction optical element for two waves which penetrates the light of wavelength $lambda_1$, and the light of wavelength $lambda_2$. When the diffraction optical element for two waves has the feature in the place which uses the above-mentioned optical element and the light of wavelength $lambda_1$ and the light of wavelength $lambda_2$ which were emitted penetrate the diffraction optical element for two

waves, the light of wavelength $lambda_2$ is diffracted with high diffraction efficiency, and the light of wavelength $lambda_1$ goes straight on -- each of two lights -- an optic axis is in agreement.

[0019]In drawing 2, the pitch P of a diffraction grating is decided that angle-of-diffraction $theta_1$ by the angle of inclination theta of the light which enters into the deflection light study element 1 for two waves from emission point 2B, and the light which enters from the emission point 2A, and the deflection light study element 1 for two waves is in agreement. By deciding in this way, the two-wave light equipment whose optic axis of the rectilinear-propagation transmitted light of wavelength $lambda_1$ and the diffracted light of wavelength $lambda_2$ which penetrated the diffraction optical element 1 for two waves corresponded is obtained.

[0020]The optical head device which carries the diffraction optical element for two waves of this invention next is explained. The semiconductor laser for two waves in which the optical head device of this invention emits the light of wavelength $lambda_1$, and the light of wavelength $lambda_2$, It has the object lens which condenses the emitted light from the semiconductor laser for two waves to an optical recording medium, the photodetector which receives the catoptric light which it was condensed and was reflected in respect of the information storage of an optical recording medium, and the further above-mentioned diffraction optical element for two waves. And this diffraction optical element for two waves is installed into the optical path between a photodetector and the object lens in the optical path between the semiconductor laser for two waves, and an object lens.

[0021]In drawing 3 (a) and drawing 3 (b), the diffraction optical element 1 for two waves is arranged between the semiconductor laser 2 for two waves, and the beam splitter 6. The light of wavelength $lambda_1$ emitted from the emission point 2A, As shown in drawing 3 (a), the diffraction optical element 1 for two waves is penetrated, on the other hand, as shown in drawing 3 (b), the diffraction optical element 1 for two waves diffracts, and the light and optic axis of light of wavelength $lambda_2$ emitted from emission point 2B of wavelength $lambda_1$ correspond. After that, the light of two wavelength turns into returned light, after it is condensed and being reflected by the object lens 3 on the optical disc 5 through the collimate lens 4.

[0022]Since the light of wavelength $lambda_1$ and the light of wavelength $lambda_2$ are on the same optic axis, each lights of wavelength $lambda_1$ and lights of wavelength $lambda_2$ which were reflected by the beam splitter 6 condense to the acceptance surface of the same photodetector 7. Therefore, detection of the optical signal of wavelength $lambda_1$ of a DVD system and the optical signal of wavelength $lambda_2$ of a CD system can be realized using the same photodetector, without increasing the area of a photodetector.

[0023]Next, other examples of the optical head device which carries the diffraction optical element for two waves of this invention are explained. In drawing 4 (a) and drawing 4 (b), the diffraction optical element 1 for two waves is arranged between the beam splitter 6 and the photo detector 7. The light of wavelength $lambda_1$ emitted from the emission point 2A (drawing 4 (a)) and the light of wavelength $lambda_2$ emitted from emission point 2B (drawing 4 (b)) turn into returned light, after it is condensed and being reflected by the object lens 3 on the optical disc 5 through the collimate lens 4.

[0024]Although the light of wavelength $lambda_1$ and the light of wavelength $lambda_2$ are on a different optic axis, as shown in drawing 4 (a), the light of wavelength $lambda_1$ reflected by the beam splitter 6 penetrates the diffraction optical element 1 for two waves, and condenses to the photodetector 7. On the other hand, as shown in drawing 4 (b), the optical element 1 for two waves diffracts, and the light of wavelength $lambda_2$ condenses to the acceptance surface of the same photodetector 7 as the light of wavelength $lambda_1$. Therefore, detection of the optical signal of wavelength $lambda_1$ of a DVD system and the optical signal of wavelength $lambda_2$ of a CD system can be realized using the same photodetector, without increasing the area of a photodetector.

[0025]It may be considered as the hologram diffraction grating which made the lattice when lattice pitch P of the false blazed diffraction grating in this invention was changed spatially (lattice position) and the diffraction grating was superficially seen from the top the shape of a curve, and a spatial phase change may be given to the diffracted light of wavelength $lambda_2$. By giving a phase change, the condensing nature to the acceptance surface top of the diffracted light of wavelength $lambda_2$ is further improvable. Although drawing 3 (a), drawing 3 (b), drawing 4 (a), and drawing 4 (b) showed the composition which used the collimate lens 4 and the object lens 3, the composition which condenses the emitted light from the semiconductor laser 2 for two waves to an optical disc only using the object lens 3 may be used.

[0026]

[Example]The diffraction optical element for two waves of this example is explained using "Example 1" drawing 1. The wavelength $lambda_1$=650nm light of a DVD system and the wavelength $lambda_2$=790nm light of a CD system enter into the diffraction optical element 1 for two waves of this example, and the section is shown in drawing 1. Here, the optical material which forms a false blazed diffraction grating is synthetic quartz of the refractive index n= 1.46. Lattice pitch P of a lattice is [30 micrometers and each level difference d] the same 1.34 micrometers altogether.

The shape of the lattice serves as a false blazed diffraction grating which has a stair-like step of the number of stages N= 4.

At this time, it was 616.4 nm, and the optical path difference was smaller than $lambda_1$=650nm, and (N-1) larger than x$lambda_2$ / N= 592.5 nm.

[0027]The size of one element of this false blazed diffraction grating is 4mmx4mmx0.53mm.

Synthetic quartz was processed and produced by the dry etching method.

In this example, while making not less than 65% of the incident light of wavelength $lambda_1$ penetrate, the diffraction optical element for two waves which can make not less than 65% of the incident light of wavelength $lambda_2$ diffract with the

$theta_1$=sin^{-1} ($lambda_2$/P) =1.51 degree degree of angle of diffraction was obtained.

[0028]The two-wave light equipment of the example of the "Example 2" book comprises the semiconductor laser 2 for two waves shown in drawing 2, and the diffraction optical element 1 for two waves obtained in Example 1. The semiconductor laser 2 for two waves has the interval W the emission point 2A of the wavelength $lambda_1$=650nm light of a DVD system and whose emission point 2B of the wavelength $lambda_2$=790nm light of a CD system are 100 micrometers, as shown in drawing 2.

The light of each wavelength is emitted from two emission points.

The emission point 2A of the semiconductor laser 2 for two waves and the interval L of 2B and the diffraction grating face of the diffraction optical element 1 for two waves are about 5 mm.
Both elements were stored in the metal packages which are not illustrated, and it fixed to them.

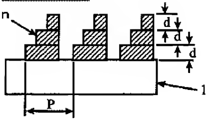
[0029]In the two-wave light equipment of this example, while making not less than 65% of the incident light of wavelength $lambda_1$ penetrate, the optic axis and uniform direction of the transmitted light of wavelength $lambda_1$ were able to be made to have been able to diffract not less than 65% of the incident light of wavelength $lambda_2$, and the optic axis of the light of two wavelength was able to be piled up. That is, the optic axis of the light of wavelength $lambda_1$ and the light of wavelength $lambda_2$ was in agreement, and the two-wave light equipment which emits the light of two wavelength to a uniform direction was realized.
[0030]The optical head device for two waves of the example of the "Example 3" book has the composition that the diffraction optical element 1 for two waves obtained in Example 1 has been arranged between the semiconductor laser 2 for two waves, and the beam splitter 6 as shown in drawing 3 (a) and drawing 3 (b). Since the diffraction optical element 1 for two waves of this invention was used, the optic axis of two emitted light from the emission point 2A when the semiconductor lasers 2 for two waves differ, and 2B could be coincided, and two emitted light has been received with one photodetector. Since the false blazed diffraction grating of the diffraction optical element 1 for two waves was used as the stair-like step of the number of stages N= 4, high transmissivity and high diffraction efficiency were acquired and the utilization efficiency of light was high. As a result, it was efficiently condensed by the acceptance surface of the same photodetector, and record and reproduction of the good stable information on S/N of both the light of wavelength $lambda_1$ and the light of wavelength $lambda_2$ were completed by small part mark.
[0031]The optical head device for two waves of the example of the "Example 4" book has composition arranged between the beam splitter 6 and the photodetector 7, as the diffraction optical element 1 for two waves obtained in Example 1 shows drawing 4 (a) and drawing 4 (b). Since the diffraction optical element 1 for two waves of this invention was used, the optic axis of two emitted light from the emission point 2A when the semiconductor lasers 2 for two waves differ, and 2B could be coincided, and two emitted light has been received with one photodetector. Since the false blazed diffraction grating of the diffraction optical element 1 for two waves was used as the stair-like step of the number of stages N= 4, high transmissivity and high diffraction efficiency were acquired and the utilization efficiency of light was high. As a result, it was efficiently condensed by the acceptance surface of the same photodetector, and record and reproduction of the good stable information on S/N of both the light of wavelength $lambda_1$ and the light of wavelength $lambda_2$ were completed by small part mark.
[0032]
[Effect of the Invention]Rather than the conventional false blazed diffraction grating, the diffraction optical element for two waves of this invention is a stair-like step of a small number of stages, can acquire the high transmissivity of light, and high diffraction efficiency, and can raise the utilization efficiency of light.
[0033]With the optical head device carried combining the semiconductor laser for two

waves which differs in this element and an emission point position, using the diffraction optical element for two waves of this invention. Since the acceptance surface of the same photodetector can be made to condense the reflected signal light from an optical disc, record and playback of the stable high information on S/N can be performed by small part mark.

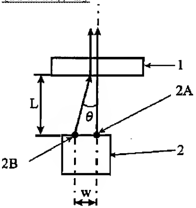
[Translation done.]

DRAWINGS

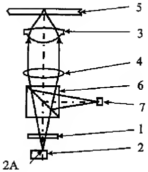
[Drawing 1]



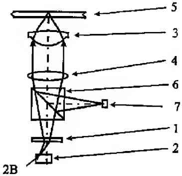
[Drawing 2]



[Drawing 3]

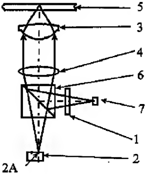


(a)



(b)

[Drawing 4]



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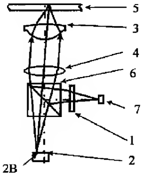
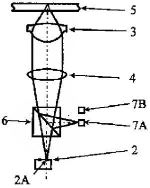
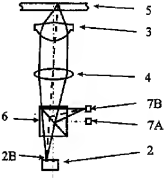


(b)

[Drawing 5]



(a)



(b)

[Translation done.]